Steel Terminology Elements Commonly Specified in Steels

Carbon is the principal hardening element in steel, and as carbon content increases the hardness increases. Tensile strength also increases with the carbon content up to about .85 per cent carbon. Ductility and weldability decrease with increasing carbon.

Manganese contributes to strength and hardness, but to a lesser degree than carbon. The amount of increase in these properties is dependent upon the carbon content. i.e., higher carbon steels are affected more by manganese than lower carbon. Manganese tends to increase the rate of carbon penetration during carburizing.

Phosphorus in appreciable amounts increases strength and hardness, but at the sacrifice of ductility and impact toughness, particularly in higher carbon steels that are quenched and tempered. Consequently. for most applications phosphorus is maintained below a specified maximum.

Sulfur. Increased sulfur content lowers transverse ductIlity and notched impact toughness, but has only a slight effect on longitudinal mechanical properties. Weldability decreases with increasing sulfur. Sulfur is added, however; to improve machinability

Silicon Is one of the principle deoxidizers used in steelmaking, and, therefore, the amount of silicon present is related to the type of steel. Silicon increases strength and hardness.

Nickel provides such properties as improved toughness at low temperatures, good resistance to corrosion when used in conjunction with chromium in stainless grades, deep hardening, and ready response to conventional methods of heat treating.

Chromium exerts a toughening effect and increases hardenability, it also improves the surface resistance to abrasionand wear and is used extensively to increase the corrosion resistance of steel.

Molybdenum promotes hardenability in steel, and is useful where close hardenability-control is essential. It increases depth-hardness and widens the range of effective heat-treating temperatures.

Vanadium is used to refine the grain size and enhance the mechanical properties of steel.

Aluminum is a reliable deoxidizer because of its great affinity for oxygen. It produces fine austenitic grain size.

Boron is a non-metallic element added to some steels primarily to improve hardenability and to increase the depth at which the steel will harden when quenched.

NOTE: Elements and mill terms are selected and adapted from a number of sources. More complete information may be found in publications of ASM, ASTM, SAE, AISI or other authoritative sources.

I. General

Rimmed Steel—A type of steel characterized by a gaseous effervescence when cooling in the mold. This results in a relatively pure iron outer rim.

Capped Steel—This is a type of steel with characteristics similar to those of rimmed steels, but to a degree intermediate between those of rimmed and semikilled steels. It can be either mechanically capped or chemically capped when the ingot is cast, but in either case the full rimming action is stopped, resulting in a more uniform composition than rimmed steel.

Semikilled Steel—Steel that is partially deoxidized so that there Is greater degree of gas evolution than in killed steel, but less than in capped or rimmed steel. The uniformity in composition lies between that of killed steel and rimmed steel.

Killed Steel—Steel deoxidized with certain deoxidizing elements, such as aluminum, silicon, etc. The term "killed" is used because such additions cause the steel to lie quietly in the molds during solidification.

Strand Casting—The direct casting of steel from the ladle into slabs, blooms or billets.
In strand casting a heat of steel Is tapped into a ladle in the conventional manner. The liquid steel is then teemed into a tundish which acts as a reservoir to provide for controlled casting rate. The steel flows from the tundish into the casting machine and rapid solidification begins in the open-ended molds. The partially solidified slab, bloom or billet is continuously extracted from the mold. Solidification is completed by cooling the moving steel surface.

Ingot—A mass of metal cast In a form convenient for storage or transportation. The cross section of most ingots approximates a square or rectangle with rounded corners. All ingots are tapered and are commonly cast big-end-down. For certain purposes, however, ingots are cast big-end-up.

Blooms—A semi-finished product rectangular in cross-section, the width not being more than double the thickness and the cross-section usually not less than 36 square inches.

Billets—Usually associated with a solid semi-finished product for further rerolling, reprocessing or reshaping, in dimensions of 2 1/2, square inch minimum to 36 square inch maximum.

Hot-rolled—Products in the "as-rolled condition" from any hot mill operation.

Cold-drawing—The process of pulling a "conditioned' bar (pickled and-limed or grit blasted) through a die for the purpose of producing a bright, smooth surface finish and close tolerances.

Centerless Grinding—Grinding the surface of a bar mounted on rollers rather than centers.

Turning—A method of cold-finishing by machining to size in a lathe or turning machine to remove surface metal formed during hot-rolling.

II. Surface Defects

Lap—A surface defect appearing as a seam caused by folding over hot metal, fins, or sharp corners and then rolling or forging them into the surface but not welding them.

Mill-shearing—A defect which can be described as a feathering type light surface lap.

Rolled-in Scale—Rolled-in oxides of iron which form on the surface of hot steel.

Scabs—Elongated patches of loosened metal which have been rolled into the surface.

Seams—Open, broken surface running in straight longitudinal lines caused by the presence of oxides near the surface.

Silvers—Surface ruptures somewhat similar in appearance to skin laminations, but usually more prominent.

III. Thermal Treatment

Heat Treatment—Heating and cooling a solid metal or alloy in such a way as to obtain desired conditions or properties. Heating for the sole purpose of hot working is excluded from the meaning of this definition.

Austenitizing—Forming austenite by heating a ferrous alloy into the transformation range (partial austenitizing) or above the transformation range (complete austenitizing).

Annealing—Heating to and holding at a suitable temperature and then cooling at a suitable rate, for such purposes as reducing hardness, Improving machinability, facilitating cold working, producing a desired microstructure, or obtaining desired mechanical, physical, or other properties. When applicable, the following more specific terms should be used: Black Annealing, Blue Annealing, Box Annealing, Bright Annealing, Flame Annealing, Full Annealing, Graphitizing, Intermediate Annealing, Isothermal Annealing, Malleablizing, Process Annealing, Quench Annealing. Recrystallization Annealing, and Spheroidizing.
When applied to ferrous alloys, the term "annealing," without qualification, implies full annealing.
When applied to nonferrous alloys, the term "annealing" implies a heat treatment designed to soften a cold worked structure by recrystallization or subsequent grain growth or to soften an age hardened alloy by causing a nearly complete precipitation of the second phase in relatively coarse form.

Full Annealing—Annealing a ferrous alloy by austenitizing and then cooling slowly through the transformation range. The austenitizing temperature for hypoeutectoid steel is usually above Ac3 and for hypereutectoid steel usually between Ac1 and Ac cm.

Spheroidizing—Heating and cooling to produce a spheroidal or globular form of carbide in steel. Spheroidizing methods frequently used are:
1. Prolonged holding at a temperature just below Ae1.
2. Heating and cooling alternately between temperatures that are Just above and just below Ae1.
3. Heating to a temperature above Ae1 or Ae3 and then cooling very slowly in the furnace or holding at a temperature just below Ae1.
4. Cooling at a suitable rate from the minimum temperature at which all carbide is dissolved, to prevent the reformation of a carbide network, and then reheating in accordance with Method 1 or 2 above.

Isothermal Annealing—Austenitizing a ferrous alloy and then cooling to and holding at a temperature at which austenite transforms to a relatively soft ferric carbide aggregate.

Normalizing—Heating a ferrous alloy to a suitable temperature above the transformation range and then cooling in air to a temperature substantially below the transformation range.

Quenching—Rapid cooling. When applicable, the following more specific terms should be used: Direct Quenching. Fog Quenching. Hot Quenching, Interrupted Quenching, Selective Quenching, Spray Quenching, and Time Quenching.

Tempering—(1) Reheating a quench hardened or normalized ferrous alloy to a temperature below the transformation range (Ac) and then cooling at any desired rate. (2) A term used in conjunction with a qualifying adjective to designate the relative properties of a particular metal or alloy induced by cold work or heat treatment, or both.

Stress Relieving—Heating to a suitable temperature, holding long enough to reduce residual stresses and then cooling slowly enough to minimize the development of new residual stresses.

Recrystallization—(1) The change from one crystal structure to another, as occurs on heating or cooling through a critical temperature (2) The formation of a new, strain-free grain structure from that existing in cold worked metal, usually accomplished by heating.

Maraging—A precipitation hardening treatment applied to a special group of iron base alloys to precipitate one or more intermetallic compounds in a matrix of essentially carbon-free martensite.

Hardenability—In a ferrous alloy, the property that determines the depth and distribution of hardness induced by quenching.

Case Hardening—Hardening a ferrous alloy so that the outer portion or case is made substantially harder than the inner portion or core.
Core—In a ferrous alloy, the inner portion that is softer than the outer portion or Case.

Carburizing—Introducing carbon into a solid ferrous alloy by holding above Ac' in contact with a suitable carbonaceous material. The carburized alloy is usually quench hardened.

Grain Size—In killed steels, grain size is specified as either coarse (grain size 1 to 5 inclusive) or fine (grain size 5 to 8 inclusive), determined in accordance with ASTM Designation El 12. Standard Methods for Estimating the Average Grain Size of Metals (by the comparison procedure).

Segregation—A phenomenon associated with solidification, which causes nonuniformity in chemical composition.

Internal Soundness—Relative freedom from segregation and porosity, as evaluated by means of a macroetch test which is performed on representative samples.

IV. Mechanical Properties

Tensile Strength—In tensile testing, the ratio of maximum load to original cross-sectional area. Also called ultimate strength.

Yield Strength—The stress at which a material exhibits a specified deviation from proportionality of stress and strain. An offset of .2% is used for many metals.

Yield Point—The first stress in a material usually less than the maximum attainable stress, at which an increase in strain occurs without an increase in stress. Only certain metals exhibit a yield point. If there is a decrease in stress after yielding, a distinction may be made between upper and lower yield points.

Elongation—In tensile testing, the increase in the gage length, measured after fracture of the specimen within the gage length, usually expressed as a percentage of the original gage length.

Reduction of Area—(1) Commonly, the difference, expressed as a percentage of original area, between the original cross-sectional area of a tensile test specimen and the minimum cross-sectional area measured after complete separation. (2) The difference, expressed as a percentage of original area, between original cross-sectional area and that after straining the specimen.

Hardness—Resistance of metal to plastic deformation usually by indentation. However, the term may also refer to stiffness or temper, or to resistance to scratching, abrasion or cutting. Indentation hardness may be measured by various hardness tests, such as Brine/I, Rockwell and Vickers.

Brinell Hardness Test—A test for determining the hardness of a material by forcing a hard steel or carbide ball of specified diameter into it under a specific load. The result is expressed as the Brinell hardness number, which is the value obtained by dividing the applied load in kilograms by the surface area of the resulting impression in square millimeters.

Rockwell Hardness Test—A test for determining the hardness of a material based upon the depth of penetration of a specified penetrator into the specimen under certain arbitrarily fixed conditions of test.

Impact Test—A test to determine the behavior of materials when subjected to high rates of loading, usually in bending, tension or torsion. The quantity measured is the energy absorbed in breaking the specimen by a single blow, as in the Charpy or lzod tests.

Charpy Test—A pendulum-type single-blow impact test in which the specimen, usually notched, is supported at both ends as a simple beam and broken by a falling pendulum. The energy absorbed, as determined by the subsequent rise of the pendulum, is a measure of impact strength or notch toughness.

Izod Test—A pendulum type of single-blow Impact test In which the specimen, usually notched, is fixed at one end and broken by a falling pendulum. The energy absorbed, as measured by the subsequent rise of the pendulum, is a measure of impact strength or notch toughness.

*With the addition of .15/.35 per cent Lead to these alloys, mechanical properties are not appreciably affected. Machinability, however, is improved approximately 25 per cent.